ATIS STANDARD

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Electrical Protection of Network-Powered Broadband Facilities

AMERICAN NATIONAL STANDARD FOR TELECOMMUNICATIONS

ATIS-0600332.2020, *Electrical Protection of Network-Powered Broadband Facilities*

Is an American National Standard developed by the ATIS **Network Electrical Protection (NEP)** Subcommittee under the **ATIS Sustainability in Telecom: Energy and Protection Committee (STEP)**.

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American National Standard for Telecommunications

Electrical Protection of Network-Powered Broadband Facilities

Alliance for Telecommunications Industry Solutions

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Abstract

This standard provides the minimum electrical protection requirements intended to mitigate the disruptive and damaging effects of lightning and ac power faults to broadband facilities. Disturbances from lightning and ac power line faults may be disruptive to broadband service and may also result in damage to the broadband plant and equipment. Head ends, switching centers and similar type facilities, outside plant cables, and the interface point at customer locations are often exposed to such disturbances, either directly or through the broadband cables and ac power facilities that serve them. Telecommunications service providers employ electrical protection measures and bonding and ground techniques to reduce the effects of such disturbances.

Foreword

The information contained in this Foreword is not part of this American National Standard (ANS) and has not been processed in accordance with the American National Standards Institute's (ANSI) requirements for an ANS. As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the Standard.

The Alliance for Telecommunication Industry Solutions (ATIS) serves the public through improved understanding between providers, customers, and manufacturers. The Sustainability in Telecom: Energy and Protection (STEP) Committee – formerly the Network Interface, Power, and Protection Committee (NIPP) – engages industry expertise to develop standards and technical reports for telecommunications equipment and environments in the areas of energy efficiency, environmental impacts, power, and protection. The work products of STEP enable vendors, operators, and their customers to deploy and operate reliable, environmentally sustainable, energy efficient communications technologies. STEP is committed to proactive engagement with national, regional, and international standards development organizations and forums that share its scope of work.

ANSI guidelines specify two categories of requirements: mandatory and recommendation. The mandatory requirements are designated by the word shall and recommendations by the word should. Where both a mandatory requirement and a recommendation are specified for the same criterion, the recommendation represents a goal currently identifiable as having distinct compatibility or performance advantages.

Suggestions for improvement of this document are welcome. They should be sent to the Alliance for Telecommunications Industry Solutions, STEP, 1200 G Street NW, Suite 500, Washington, DC 20005.

At the time it approved this document, STEP, which is responsible for the development of this Standard, had the following leadership:

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J. Fuller, STEP Vice-Chair (AT&T)

D. Ashton, STEP NEP Chair (CenturyLink)

The Network Electrical Protection (NEP) Subcommittee was responsible for the development of this document.

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Electrical Protection of Network-Powered Broadband Facilities

1 Scope, Purpose, & Application

1.1 Application of Electrical Protection

The electrical protection, bonding, and grounding measures presented in this standard are intended to assist in protecting persons, equipment, and property from the effects of lightning, commercial ac power system faults, and electromagnetic interference (EMI) on the Network-powered broadband facilities.

1.2 Facilities Covered

This standard applies to the electrical protection, bonding, and grounding of network-powered broadband facilities at the headend, in the outside plant, and at the customer location (including the entrance or interface point). In some cases, the headend and the switching center might be collocated. These facilities may consist of paired conductor cable, optical fiber cable, or coaxial cable, either singularly or in any combination. The facilities may be aerial, buried, or underground.

The typical basic system configuration includes a cable supplying power and network-powered broadband signal to a network interface unit (NIU) that converts the network-powered broadband signal to the component signals. Typical cables are coaxial cable with both network-powered broadband signal and power on the center conductor, composite metallic cable with a coaxial member for the network-powered broadband signal and twisted pair(s) for power, and composite optical fiber cable with twisted pair(s) for power. Article 830 of National Electric Code® (NEC®) covers network-powered broadband communications systems at customer's structures or buildings, extending from the power-passing tap to the NIU.

1.3 Items Not Covered

Although a variety of existing and proposed network-powered broadband architectures are considered, the merits of the different technologies, and/or architecture types, are not covered.

The following items are also not covered by the standard:

- In-Premises wiring and components.
- Other customer premises equipment (CPE) from the network interface inward.
- Span-Powering, Power-over-Ethernet (PoE) and G.fast network applications – ATIS is currently developing standards covering the powering limits and electrical protection aspects of these architectures and applications.
- Specific EMI mitigation designs.
- Specifications for primary protectors.
- Microwave systems.
- Subscriber radio systems.
- Communications circuits as covered by National Electric Code® (NEC®) Article 800. Other ATIS standards such as ATIS-0600313 [Ref 4], ATIS-0600316 [Ref 5], and ATIS-0600318 cover these communications circuits.
- CATV as covered by NEC® Article 820.

2 References

The following standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this American National Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

2.1 Normative

[Ref 1] ANSI/IEEE C2®, *National electrical safety code*.[1]

[Ref 2] ANSI/IEEE 367®, *Recommended practice for determining the electric power station ground potential rise and induced voltage from a power fault*.[1]

[Ref 3] ANSI/IEEE 776®, *Guide for inductive coordination of electrical supply and communication lines*. [1]

[Ref 4] ATIS-0600313, *Electrical protection for telecommunications central offices and similar type facilities*.[2]

[Ref 5] ATIS-0600316, *Electrical protection of telecommunications outside plant*.[2]

[Ref 6] IEEE 81, *Guide for measuring earth resistivity, ground impedance, and earth surface potentials of a ground system*.[3]

[Ref 7] NFPA 70®, *National electrical code (NEC®)*.[4]

[Ref 8] NFPA 780®, *Standard for Installation of lightning protection systems*, 2000 edition.[4]

2.2 Informative

[Ref 101] ANSI C62.41.1, *IEEE Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.*

[Ref 102] ANSI C62.41.2, *IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits.*

[Ref 103] ANSI C62.45, *IEEE Guide on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.*

[Ref 104] ATIS-0600328, *Protection of telecommunications links from physical stress and radiation effects and associated requirements for DC power systems (A Baseline Standard).*

[1] For electronic copies of some standards, visit ANSI's Electronic Standards Store (ESS) at < www.ansi.org >. For printed versions of all these standards, contact Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112-5704, (800) 854-7179.

[2] This document is available from the Alliance for Telecommunications Industry Solutions (ATIS) at: < https://www.atis.org/ >.

[3] This document is available from the Institute of Electrical and Electronics Engineers (IEEE) at: < https://www.ieee.org/publications_standards/index.html >.

[4] This document is available from the National Fire Protection Association (NFPA) at: < http://www.nfpa.org/codes-and-standards >.

3 Definitions and Acronyms

3.1 Definitions

Unless otherwise defined in this clause, the definitions of all terms used in this standard conform to ANSI/IEEE Standards Dictionary Online located at https://innovate.ieee.org/ieee-standards-dictionary-online/ .

Bonded signal conductor: Signal conductor intentionally connected to other metallic members of a cable or equipment through a frequency selective connection(s) presenting low impedance to the currents in the frequency range other than that of the broadband signal being transmitted and including direct current. Bonding of signal conductors is generally transparent to the broadband signal and may be applied to the non-powered signal conductors.

Drop (cable): The communications service cable, which connects the subscriber interface (network interface unit or NIU) to the serving terminal.

Effectively bonded signal conductor: Bonded signal conductor (see definition in Clause 3.1) where the bonding connection is of sufficiently low impedance and having sufficient current-carrying capacity to prevent buildup of voltages on this conductor that may result in undue hazard to connected equipment or to persons. When primary protection operates, effective bonding of signal conductors is achieved; however, it is not transparent to any broadband signals that may be present.

Electronic equipment enclosure: An electronic equipment enclosure (EEE) is an enclosure housing telecommunications equipment. It may consist of a weatherproof enclosure, equipment pod, or an equipment hut. The EEE may be located remotely from a central office or a headend. The EEE may be located above or below ground. The temperature and humidity within the EEE may be controlled. The EEE is served by telecommunications outside plant facilities, which may be aerial, directly buried, or placed in underground conduit. It may also be served by commercial ac power facilities and may have provisions for standby power.

Hard line (equipment): The coaxial distribution cables are referred to as *hard line* owing to their construction, which utilizes solid metal sheath design.

Indoor Unit: In broadband wireless system the equipment, receiving or transmitting or both, associated with premises distribution system that are located indoors; i.e., not exposed directly to weather.

Inter Facility Link: In wireless installations, the entire segment of the bundled drop cable (outdoor and indoor) between the ODU and the IDU. A typical installation may involve one or more coaxial cables, multiple twisted pair cable, and possibly a fiber optic cable. An IFL may carry low or high power RF broadband signal, control signals, and DC or AC current used to power the serving terminal equipment (ODU).

Network-powered broadband communications circuit: (per ANSI/NFPA 70® [Ref 7]**, Article 830):** The circuit extending from the communications utility's serving terminal or tap up to and including the NIU.

> NOTE - A typical single-family network-powered communications circuit consists of a communications drop or communications service cable and an NIU and includes the communications utility's serving terminal or tap where it is not under the exclusive control of the communications utility.

Network Interface Unit (per ANSI/NFPA 70® [Ref 7]**, Article 830):** A device that converts a broadband signal into component voice, audio, video, data, and interactive services signals. The NIU provides isolation between the network power and the premises signal circuits. The NIU may also contain primary and secondary protectors.

Outdoor Unit: In broadband wireless system, the serving terminal equipment (receiving or transmitting or both) located in the proximity of the antenna. In very small installations this term may refer to the entire antenna-equipment assembly.

Plastic (Polyolefin) Insulated Conductor: Solid copper conductors insulated with polyolefin or plastic material that are used in twisted–pair cables.

Reference Point 0: The point at which all ground categories within the facility shall be referenced to earth. Reference Point 0 is identical to the Building Principal Ground (BPG) of ATIS-0600333, Grounding and Bonding of Telecommunications Equipment.

Tap: The multiport serving terminal device installed on the hard line distribution cable providing interface between the coaxial service drop cable and the broadband telecommunications plant distribution network.

3.2 *Acronyms*

ANSI	American National Standards Institute
AWG	American Wire Gauge
BPG	Building Principal Ground
CATV	Community Antenna Television
CPE	Customer Premises Equipment
EEE	Electronic equipment enclosure
EHV	Extra high voltage
EMI	Electromagnetic Interference
GPR	Ground potential rise
IDU	Indoor Unit
IEEE	Institute of Electrical and Electronics Engineers
IFL	Inter Facility Link
LPS	Lightning protection system
MGN	Multi-grounded neutral
NEC	National Electrical Code
NESC	National Electrical Safety Code
NFPA	National Fire Protection Association
NIU	Network Interface Unit
NRTL	Nationally recognized test laboratory
ODU	Outdoor Unit
PIC	Polyolefin Insulated Conductor
RP 0	Reference Point 0
SPD	Surge protective device
USAT	Ultra-small aperture terminal
VSAT	Very small aperture terminal

4 Exposure

4.1 Sources of Exposure

Broadband facilities might be exposed to unwanted voltages and currents resulting from any of the following:

- Disturbances from lightning;
- Contact with electric power circuits;
- Ground potential rise;
- Induction from electric power lines; or
- Resistive coupling in coaxial distribution systems.

4.1.1 Lightning Disturbances

Lightning can create disturbances to the broadband facilities by either a direct strike to a broadband facility or by a strike near the facility. Some of the lightning's electromagnetic energy could also be coupled to the power wires or to the cables carrying telecommunications or broadband signals. The level of exposure should be determined from the Risk Assessment Guide contained in Appendix L of ANSI/NFPA 780® [Ref 8].

Outside plant cables, either aerial or buried, may be subject to effects of lightning. A buried broadband cable or wire can become a conductor of lightning currents resulting from nearby strokes to the earth.

A determination of the exposure status of broadband facilities shall take into account both the exposure of the structure itself (e.g., central office, headend, or EEE), as well as the outside plant cables that serve them.

4.1.2 Contact with Power Circuits

Power, broadband, and telecommunications companies (utilities) often serve the same customers and frequently employ joint-use outside plant facilities such as poles or common trenches. Clearances and separations for joint-use facilities are regulated by either ANSI/IEEE C2 (NESC®) [Ref 1] or local codes. Power contact may result from a falling phase conductor into aerial plant or during excavations in buried plant areas.

4.1.3 Ground Potential Rise (GPR)

During normal conditions, the power system's grounded neutral conductor is generally at the same potential as remote earth. GPR occurs during a power fault when the fault current returns to its source through the earth. During fault conditions, the potential at the local ground of the broadband facilities rises with respect to remote earth.

4.1.4 Power Induction

Power and telecommunications (broadband) outside plant facilities frequently occupy joint structures or a common right-of-way, and as such occupy parallel routes. The proximity of broadband metallic cables to power lines can result in voltages being induced on the broadband metallic facilities by either magnetic or electric fields.

4.1.4.1 Magnetic Field Induction

The varying magnetic fields produced by currents in a nearby power line may result in large voltages being induced into the broadband outside plant facility through inductive coupling, especially under certain conditions on the power facility such as a phase-to-neutral fault.

4.1.4.2 Electric field induction

Ungrounded broadband outside plant cables, hardware, and personnel located in the vicinity of extra high voltage (EHV) power transmission lines (greater than 300 kV phase-to-phase) may become electrically energized by electrostatic coupling to the EHV power lines. An ungrounded object – including a person – will assume a potential relative to the earth, based upon the voltage and geometry of the power line and the capacitance of the object, or person, with respect to both the power line and the earth. The induced voltages can be quite large and the available current is usually quite small (below the level that might cause electrical injury). However, the resulting electric shock or arc may be startling, causing accidental injury as a result of an involuntary reaction.

Grounding (earthing) of broadband cables and hardware helps to minimize the possibility for injury, resulting from such involuntary reactions, by keeping the cables and hardware and the earth near them at the same potential.

4.1.5 Resistive Coupling

Coaxial cable distribution systems in joint use with commercial ac power systems are subject to resistive coupling. Resistive coupling occurs when the coaxial cable shield, which is bonded to the neutral of the power distribution system for safety, provides an alternate path for the power distribution system neutral current. The current of the power distribution system present in the coaxial cable shield, because of the shield resistance, will cause center conductor-to-shield voltages to be coupled into the coaxial cable. The magnitude of these voltages is dependent upon the shield current and the mutual impedance between the coaxial cable shield and center conductor. Resistively coupled voltages, under power fault conditions, can be sufficiently high as to require electrical protection.

4.2 Classification of Exposure

A determination of the exposure status of a broadband facility shall take into account both the exposure of the structure itself (e.g., central office, headend, or EEE), as well as the outside plant cables that serve it. Any facility that is classified as exposed shall require coordinated electrical protection.

Underground construction methods, by design, help to eliminate the possibility of power contacts. Cables in conduit on bridges and underpasses are treated the same as underground cables. Cables mounted on bridge supports are treated as aerial cable. Submarine cable is regarded as buried cable.

4.2.1 Exposure to Lightning

A broadband facility shall be classified as exposed to lightning unless it is located in an area having an average of five (5) or fewer thunderstorm-days per year and earth resistivity of less than 100 ohm-meters as measured in accordance with IEEE 81® [Ref 6] Guide for measuring earth resistivity, ground impedance, and earth surface potentials of a ground system.

Structures or cables that are located at elevations significantly above the average elevation of the surrounding terrain such as hill-tops, fire towers, and airport control towers, are considered exposed to lightning regardless of thunderstorm incidence and earth resistivity.

Broadband facilities should be classified as unexposed to lightning when located in a geographic area treated as unexposed by the serving utility. This area may be a metropolitan location (also called a block) having a high density of multi-story buildings and an extensive network of buried metallic piping systems and cables. In these areas, lightning-induced surges are unlikely to enter the facility through the serving cables, which are effectively shielded and grounded (earthed). Although the facility itself may not be within the zone of protection of a higher structure, the risk of damage from a direct lightning stroke is considered a low probability event.

4.2.1.1 Structures

A structure or building shall be classified as exposed if the broadband outside plant serving it, or the commercial ac power serving it, is exposed to lightning.

Each structure intended to house a switching or transmission system should be evaluated to determine the need for a lightning protection system (LPS). The decision on whether or not to provide an LPS should be based on the Risk Assessment Guide contained in Appendix L of ANSI/NFPA 780® [Ref 8].

4.2.1.2 Central Office, Remote Site, & Headend

A central office, headend, or EEE structure shall be classified as exposed if

(a) The broadband outside plant connected to it,

(b) The telecommunications outside plant serving it, or

(c) The commercial ac power serving it, is exposed to lightning.

By their very construction, radio antennas/towers are considered exposed to the possible damaging effects of lightning. Tall structures, such as towers, buildings, and antenna masts, provide a favorable discharge point for lightning strokes.

4.2.1.3 Outside Plant

Aerial outside plant should be considered exposed to lightning, in general. Only a few geographical areas qualify as non-lightning areas (see Clause 4.2.1).

Outside plant facilities containing no metallic members or with no metallic conductors, such as all-dielectric optical fiber cables, are considered unexposed to lightning and power. However, in locations exposed to lightning, buried all-dielectric optical fiber cables may be subject to collateral damage during an arcing event of lightning to nearby underground metallic objects.

Broadband network facilities shall be classified as exposed if they serve a customer location that is classified as exposed to lightning.

Inter-building cable runs of 140 feet (43 meters) or less, directly buried or in underground conduit where a continuous metallic cable shield or a continuous metallic conduit containing the cable is bonded to each building grounding electrode system, should be considered as unexposed to lightning. Examples are campus environments and short inter-building cables.

4.2.1.4 Customer Locations

A determination of the exposure status of a customer location shall take into account both the exposure of the structure itself as well as the broadband facilities that serve the structure. Any broadband facility serving a customer location that is classified as exposed shall require coordinated electrical protection at the entrance to the customer structure or location.

4.2.2 Exposure to Power Contact

Broadband facilities shall be considered exposed to power contact when the possibility exists for contacting a power conductor operating at 300 volts rms or greater to ground (earth). All aerial outside plant place on joint use poles is generally considered exposed to power unless confined within a block as defined in ANSI/NFPA 70® (NEC®) [Ref 7].

Joint random buried plant – i.e., power and broadband cables directly buried in the same trench with no deliberate separation – shall be considered exposed to power contact.

Even when unexposed to power contact, some direct buried outside plant that parallels power conductors for long distances is subject to induction. Regardless of parallel distance, some direct buried outside plant is also subject to ground potential rise resulting from power faults.

4.2.3 Exposure to Ground Potential Rise (GPR)

A broadband facility shall be considered exposed to GPR if the possibility exists that local ground may differ from remote earth by 300 volts rms or greater as determined by methods presented in ANSI/IEEE 367® [Ref 2].

4.2.4 Exposure to Power Induction

A broadband facility shall be considered exposed to power induction when the possibility for induced voltages in excess of 300 volts rms to ground exists as determined by methods presented in ANSI/IEEE 367® [Ref 2] or ANSI/IEEE 776® [Ref 3].

5 Electrical Protection Considerations

5.1 General

Maintaining the continuity of metallic members in the broadband network plant, together with the bonding and grounding of these metallic members (and coaxial cable shields, where present), serves to limit lightning and ac power fault voltages and provides a controlled path for lightning and ac power fault currents. At the terminus of the broadband network plant, such as at the customer or the headend, bonding and grounding of metallic members, together with the application of a listed primary protector (listed for the purpose by a Nationally Recognized Testing Laboratory), serves to limit lightning and ac power-fault voltages. A listed primary protector shall be applied to the broadband facilities at the customer and at the headend under the following conditions:

- The broadband network plant, serving ac power service, or the building or structure containing broadband facilities is exposed to lightning;
- The broadband network plant is exposed to possible power contact or induction in excess of 300 volts rms to ground;
- The building or structure containing broadband facilities is exposed to possible ground potential rise in excess of 300 volts rms with respect to remote earth.

Where paired-conductor and coaxial cables are exposed to power contact greater than 300 volts rms to ground, a fuse link shall be applied to limit power currents to a value that can be safely carried by the listed primary protector. There shall be no exposure to power contact between the fuse link location and the terminus of the broadband network plant. Both the voltage-limiting and current-limiting functions may be incorporated in the listed primary protector.

Isolation techniques may also be used in areas where stray dc currents contribute to electrolysis (corrosion).

The broadband network plant may be paired-conductor, optical fiber, or coaxial cable, or a composite cable containing any combination of these, together with amplifiers, power-passing taps, and NIU to distribute the broadband services to customers.

5.1.1 National Electrical Code Considerations

Article 830 of ANSI/NFPA 70® (NEC®) [Ref 7] covers the installation of broadband facilities at customers' structures or buildings, extending from the power-passing tap to the NIU. However, Article 830 does not explicitly address the customer powered serving terminals (such as antenna mounted radio equipment) used for delivery of broadband services (see Clause 8.2.1.1). Article 840 of the NEC covers networks that are powered from the customer premises

Article 810 of ANSI/NFPA 70® [Ref 7] covers the installation of the Radio and Television Equipment. Sections 810.15 and 810.21 specify the grounding requirements for the masts and metal structures supporting antennas. ANSI/NFPA 70® [Ref 7] does not distinguish between the exposed and unexposed location of the antenna.

However, the NEC® does not cover installations of broadband facilities under the exclusive control of the broadband utility, located outdoors or in building spaces used exclusively for such installations – see ANSI/NFPA 70® [Ref 7], Article 90.2(B)(4). Grounding is covered in Article 800 and 250 of the NEC®. Although the NEC® does not cover broadband facilities under the exclusive control of the broadband utility, such as the headend office, such installations should conform as closely as possible to the appropriate articles of the NEC.

On the customer side (i.e., output circuits) of the NIU, the NEC® applies as indicated in Table 1. Articles 770 and 800 of ANSI/NFPA 70® [Ref 7] cover the installation of telecommunications facilities at customer's structures or buildings.

ANSI/NFPA 70® [Ref 7] distinguishes between optical fiber cables that contain metallic pairs and those that do not. Those that contain metallic pairs are treated as communication cables per Article 800; those containing no metallic pairs are treated as optical fiber cables per Article 770.

Article 820 of ANSI/NFPA 70® [Ref 7] covers the installation of the Community Antenna Television and Radio Distribution Systems.

Requirements of the most recent edition of ANSI/NFPA 70® [Ref 7] shall be met except where superseded by local electrical codes.

Table 5.1 – Application of ANSI/NFPA 70 (NEC) at the output circuit of the NIU

Technology/Service	Appropriate NEC Article
Communications Circuits	Article 805
Installations of Communications Circuits	Article 805
Installations of Class 2 and Class 3 circuits	Article 725
Installations of power-limited fire alarm circuits	Article 760
Installations of Optical Fiber Cable	Article 770
Installations of Community Antenna Television (CATV)	Article 820
Installations of Customer Premises Powered Circuits	Article 840

5.1.2 National Electrical Safety Code Considerations

In addition to bonding, grounding, and the maintenance of continuity of metallic members of broadband network plant, electrical protection considerations include proper physical separation and spacing. Physical separation between broadband network plant and commercial ac power distribution systems occupying joint-use structures (such as poles) are intended to provide for the safety of broadband utility personnel as well as the customers. The requirements for utilities occupying joint-use structures, as well as direct buried and underground installations, are contained in ANSI/IEEE C2® (NESC®) [Ref 1].

5.2 Bonding & Grounding

The objective of bonding is to equalize potential between conductive parts such as between metallic members of multiple broadband cables. Grounding provides a means for removing unwanted electrical energy (lightning, ac power influences) from metallic members of the broadband facilities. At the terminus of the broadband facilities, such as the customer NIU and the headend office, metallic members and shields are grounded to remove lightning and ac power fault voltages. Metallic members and shields of multiple cables appearing at these locations are bonded together to equalize potentials for personnel safety.

In the broadband network distribution plant, low-impedance paths to ground serve to mitigate damage to broadband distribution plant from both lightning and ac power faults. When broadband network distribution plant is run jointly with multi-grounded neutral (MGN) power, the MGN is usually the lowest impedance path to ground available. Bonding of metallic members and support strands to the MGN serves to remove lightning currents as rapidly as possible from the broadband network distribution plant, minimizing the amount of plant damaged during a lightning event. In the case of a power contact, bonding to the MGN provides a low impedance return path to the power neutral to help limit voltage on the broadband distribution plant and permits the operation of the power distribution system overcurrent protective devices (fuses or circuit breakers) to clear the power contact fault. Bonding of metallic components to support strands and bonding together of metallic components and support strands of separate cables, helps to equalize potential between conductive parts for personnel safety and to minimize arcing damage because of lightning or power contact.

5.3 Primary Protectors

A listed primary protector, applied to paired conductors or to the center conductor of a coaxial cable, helps to limit the voltage difference between the paired-conductors and ground or between the center conductor of the coaxial cable and shield. It provides a path to ground when the operating voltage of the listed primary protector is reached, thereby minimizing arcing within the broadband network plant and diverting lightning and ac power fault currents away from broadband equipment.

5.4 Fuse Links

A fuse link serves to limit current, under power contact conditions to a value that can be safely carried by the listed primary protector. A fuse link is not intended to protect cable or the customer structure or building from lightning damage. Fuse links are applicable to both paired-conductor and to coaxial broadband network plant and are typically employed wherever there is a possibility of power contact of 300 volts rms or greater to the broadband network plant.

5.5 Current-Limiting Devices

Current-limiting devices are employed on paired-conductor broadband plant at the headend or central office to limit low-level currents that result from voltage levels too low to operate the listed primary protector. These devices limit current to a level that can be safely carried by headend office wiring, cross-connects, and wiring terminals. Current-limiting devices are not intended to protect against lightning damage.

6 Switching Centers, Head-ends, & Similar Type Facilities

6.1 Protection of Entrance Facilities (Telecommunications)

All exposed cables containing metallic components entering a facility require some form of electrical protection at the switching center, headend, or similar type facility. The metallic components include items such as metallic shields, metallic strength members, metallic pairs, coaxial conductors, or metallic vapor barriers. Electrical protection includes bonding and grounding of cable metallic sheath components and metallic strength members, and application of protectors to metallic pairs, broadband powering conductors, and coaxial cable center conductors, along with fuse links and other current limiters (e.g., heat coils) where required.

Cables containing no metal components – such as all-dielectric optical fiber cables ***without*** metallic pairs, strength members, shields, or vapor barriers – are considered unexposed and require no electrical protection.

6.1.1 Protectors

Protectors shall be installed on all exposed communications paired conductors, coaxial cable center conductors, and broadband system powering conductors that enter the switching or headend facility. The protector ground terminals shall be connected to Reference Point 0 (RP 0).

6.1.2 Bonding & Grounding

The switching or headend facility principal ground point (e.g., RP 0 in ATIS-0600313 [Ref 4]) is the location where all grounding conductors ultimately connect to the earth electrode. The major emphasis of bonding and grounding is to maintain potential equalization between the equipment ground, power ground, metallic cable sheath components, cable metallic strength members, protector grounds, and the facility principal ground point. Coaxial cable shields, metallic shields of paired conductor cables, metallic strength members, and metallic vapor barriers of all entering cables shall be bonded together at the point of entrance (usually the cable entrance facility or cable vault) and grounded to the facility principal ground point. Copper conductors of 6 AWG or coarser should be used. In telecommunications switching facilities, this is typically accomplished by bonding to the copper conductor that is run from the cable entrance facility or cable vault to the principal ground point.

6.1.3 Protector Coordination

The wire gauge of telecommunications pairs, powering conductors, and coaxial cable center conductors entering the switching center, headend, or similar type facility shall coordinate with the voltage limiting protector when the outside plant is exposed to possible contact with power. This is necessary to prevent the protector from overheating and becoming a fire hazard. This is accomplished by including a fuse link, placed in series with the conductor, between the switching or headend facility and the point of possible power contact.

For conventional paired-conductor copper telecommunications plant, the gauge of the cable conductors may be selected so that the conductors themselves serve as the fuse link. Typically, a cable containing copper conductors no coarser than 24 AWG is used. If the conductors are coarser than 24 AWG, a fusing element in the form of a minimum two-foot (0.75 meter) length of cable no coarser than 24 AWG is inserted in the coarser gauge cable between the exposure and the switching or headend facility. Table 6.2 contains fuse cable requirements for conventional paired-conductor copper telecommunications plant. For powering conductors and coaxial cable center conductors that are too coarse to serve as the fuse link, a finer section (i.e., having a smaller diameter) of conductor (or fuse) shall be inserted in the powering conductor or coaxial cable center conductor between the exposure and the switching or headend facility.

Table 6.1 – Fuse Cable Requirements

Entrance Cable	Fuse Cable	Connector Stub
19 or 22 AWG	24 AWG	22 AWG
19 or 22 AWG	26 AWG	24 or 22 AWG
24 AWG	NONE	22 AWG
24 AWG	26 AWG	24 AWG
26 AWG	NONE	24 or 22 AWG
NOTE 1 - Any intervening conductor between the entrance cable and the tip cable or connector stub must be the same gauge as, or coarser than, the tip cable or connector stub. NOTE 2 - The metric equivalents are: • 26 AWG = 0.405 mm (diameter) • 24 AWG = 0.511 mm • 22 AWG = 0.644 mm • 19 AWG = 0.910 mm		

6.1.4 Application of Current-Limiting Devices

Current-limiting devices should be considered on conductors that are exposed to power when required by terminal equipment characteristics. Current-limiting devices are intended to operate on currents in excess of approximately 0.5 amperes that are driven by voltages that are below the operating level of the voltage-limiting protector. For conventional paired-conductor copper communications cables, current-limiting devices should be considered on exposed pairs entering the facility under the following conditions:

- A conductor of the pair can draw in excess of 3 amperes rms when up to 300 volts rms is applied continuously;
- A conductor of the pair can draw in excess of 10 amperes rms when up to 600 volts rms is applied for 5 seconds;
- The equipment or its interconnecting wiring becomes a fire hazard for conductor currents in excess of 0.35 amperes rms and driving voltages up to 600 volts rms, applied continuously.

For powering conductors of larger gauge than contained in conventional paired-conductor telecommunications cables and for coaxial cable center conductors, the need to apply current-limiting devices shall be determined by the current carrying capacity of the interconnecting wiring or coaxial cable used and the characteristics of the terminal equipment.

6.2 Protection of Entrance Facilities (Commercial AC)

The commercial ac power feeding the structure should meet the appropriate requirements of the NEC. The main disconnect panel should include a neutral bus bar which connects the neutral (grounded) conductor to an earth (grounding) electrode meeting the requirements of NEC® 250.50.

The main disconnect panel's neutral bus bar (N) should be bonded to the ground bus bar (G) via the main bonding jumper as required by NEC® 250.28.

If the site is co-located with a central office, one or more separate and dedicated branch panel(s) should be used to feed ac power to the headend equipment room.

> NOTE - Do not install a bonding jumper between N (Neutral) and G (Ground) unless a separately derived source is used.

6.2.1 Determining Exposure

A central office, headend, or EEE structure shall be classified as exposed if the commercial ac power serving it is exposed to lightning.

6.2.2 Sources of Overvoltage on the Serving ac Power Facility

6.2.2.1 Lightning

- Direct stroke or induced surge on an ac transmission or distribution system;
- Ground return current flow resulting from nearby discharges to the earth.

6.2.2.2 Other

- Switching surges (e.g., switching of power factor correction capacitors);
- Load switching within the headend and switching center (e.g., switching to ac and dc power conversion equipment, elevator loads);

- Other over-voltage disturbances can be generated by the resonating circuits associated with commutating devices (e.g., thyristor-controlled rectifiers or excessive power factor correction capacitance);
- Power faults (bolted and arcing faults).

6.2.3 Application of Surge Protective Devices

A surge protective device (SPD) shall be required on the ac power service facilities:

- As determined by local conditions;
- When power line disturbance monitoring (over at least one lightning season) indicates a need for an SPD. (See ANSI/IEEE C62.41®[5])

Where SPDs are required, protection should be applied both on the primary and on the secondary ac service to the headend, central office, or similar facility as well as at downstream panelboards as required.

6.2.3.1 Primary Distribution Class SPD

These devices are usually provided by the power utility for use on the high voltage side (power utility side) of the ac power distribution transformer.

6.2.3.2 Secondary Class SPD

Typically these devices are applied on the load side of the primary service disconnect as close as practicable to the service disconnect (ANSI/IEEE C62.41® Category C). All conductors connecting the SPD to the ac power or ground shall not be any longer than necessary (preferably not to exceed 3 feet [1 meter]) and shall contain no sharp bends or loops.

Significant performance improvements through impedance reductions are realized when steel conduit is used for the SPD conductors and when these conductors are tightly taped together within the conduit.

6.2.3.3 Utilization SPD

Utilization SPDs should be applied as required at specific load locations and coordinated with the secondary SPD. Characteristics of the utilization SPD shall coordinate with the surge withstand voltage capabilities of the equipment being protected.

6.3 Microwave Towers & Satellite Dishes

6.3.1 Structure Grounding Requirements

All headend towers and satellite dish mountings shall be grounded in accordance with industry-accepted practices and methods (see ATIS-0600313 [Ref 4], Clause 10). If there is an equipment building associated with a tower, the tower grounding electrode system shall be bonded to the equipment building grounding electrode system, described in 6.3.3, with at least two 2 AWG or coarser uninsulated solid copper conductors, buried at a minimum depth of 18 inches (0.5 meters).

[5] See Clause 2.2 for more information on this standard.

If there are other metallic elements – such as a metal fence or engine generator frame – within 10 feet (3.0 meters) of the tower, the tower grounding electrode system shall be bonded to the metallic element with a 6 AWG or coarser uninsulated solid copper conductor. All bonding connections shall be either an exothermic weld or a listed compression connector.

Roof mounted towers increase the lightning risk for the buildings upon which they are placed. Therefore, all exposed buildings with roof-mounted towers shall be equipped with a LPS as outlined in ANSI/NFPA 780® [Ref 8]. Additional bonding considerations for roof-top towers are covered in 10.3.3 of ATIS-0600313 [Ref 4].

6.3.2 Equipment Building Grounding Requirements

Figure 3 of ATIS-0600313 [Ref 4] defines acceptable methods of grounding buildings containing radio equipment. Other industry-accepted methods may also be employed. The equipment building grounding electrode system shall be bonded to the tower grounding electrode system with a 2 AWG or coarser uninsulated solid copper conductor. Other metallic elements shall be bonded as described in 6.3.1 of this document.

Radio equipment buildings shall have an interior grounding system consisting of a 2 AWG or coarser copper conductor mounted to the interior wall within 1 foot (0.30 meter) of the ceiling. The interior grounding system shall be bonded to the exterior ground ring with 2 AWG or coarser uninsulated solid copper conductor at each building corner, routed as short and straight as possible.

6.3.3 Waveguide & Coaxial Cable Grounding Requirements

For a metallic tower structure, the waveguide and coaxial shield shall, as a minimum, be bonded to the tower at the top and bottom of the tower. Where the waveguide or coaxial cable enters a building, the waveguide or coaxial shield shall be bonded to the building grounding electrode system with a 6 AWG or coarser uninsulated solid copper conductor. For additional details, see Clause 10.5 of ATIS-0600313 [Ref 4].

If there is a metallic waveguide or coaxial cable entrance plate, the entrance plate shall be bonded to both the exterior and interior grounding system with a 6 AWG or coarser uninsulated solid copper conductor. The waveguide or coaxial shield shall be bonded to the metallic entrance plate on both the outside and inside of the building with a 6 AWG or coarser uninsulated solid copper conductor. Coaxial cable shall be protected by a SPD which is bonded to the building grounding electrode system as close to the cable entrance as possible.

6.3.4 Equipment Grounding Requirements

All equipment within a radio equipment building shall be bonded to the interior grounding system. For a line of bay frames connected with a copper grounding bar, the grounding bar shall be bonded to the interior ground ring at each end with a 6 AWG or coarser uninsulated copper conductor. Bay frames not connected with a copper bus grounding bar shall be bonded individually to the interior ground ring with 6 AWG or coarser uninsulated copper conductors.

Electrical apparatus cabinets – housing such equipment as air conditioning, lighting, or control systems – shall be bonded to the interior ground ring with a 6 AWG or coarser uninsulated copper conductor. Other metallic objects – such as battery stands, storage cabinets, and other electrical or mechanical units – shall be bonded to the interior ground ring with a 6 AWG or coarser uninsulated copper conductor.

SPDs shall be provided on the ac power service entrance and bonded to the interior ground ring with a 6 AWG or coarser uninsulated copper conductor. The power system neutral shall be bonded to the exterior ground ring with a 6 AWG or courser uninsulated copper conductor.

Metallic telecommunications facilities entering the building shall terminate in a listed primary protector, which is bonded to either the exterior or interior ground ring depending on its physical location, with a 6 AWG or coarser uninsulated copper conductor.

Optical fiber telecommunications facilities with metallic shields or strength members shall have the continuity of their metallic components interrupted to form a six-inch (15 centimeters) isolation gap within five feet (1.5 meters) of entering the building. The shield on the field side of the isolation gap shall be bonded to the interior ground ring with a 6 AWG or coarser uninsulated copper conductor.

7 Outside Plant Cables & Equipment

7.1 General Exposure Considerations

The decision to classify a particular outside plant broadband facility as exposed involves judgment. The physical characteristics of the outside plant must be considered – i.e., does a cable contain metallic members or metallic conductors?

Previous experience in a particular geographical area may also help determine the level of electrical protection required. For example, where outside plant broadband facilities are exposed to lightning, previous experience may be useful in coordinating cable dielectric specifications.

An individual segment of outside plant may itself be unexposed to lightning or power, but through exposure of laterals connecting to that segment, it too should be classified as exposed. The effects of planned or expected future rearrangements should also be considered when determining the exposure status of outside plant broadband facilities.

Any outside plant broadband facility that is classified as exposed shall require coordinated electrical protection.

7.2 Aerial Plant & Equipment

Aerial outside plant facilities are almost always exposed to lightning. Only a few geographical areas qualify as non-lightning areas (see Clause 4.2.1). Outside plant broadband facilities may be classified as unexposed to lightning if it is located in an area treated as unexposed by the owning utility. Such an area may be a metropolitan or urban location having a high density of multistory buildings and an extensive network of buried metallic piping systems and cables. In these areas, the outside plant broadband facilities are effectively shielded from lightning-induced surges. However, aerial construction is seldom used in such high-density metropolitan areas.

Aerial outside plant containing no metallic members or metallic communications conductors – such as all-dielectric optical fiber cable – is considered unexposed to lightning and power.

Aerial outside plant should be considered exposed to power, even if power is not present, since for practical design purposes, one needs to assume that power conductors will not be installed at a later time. Aerial outside plant is generally considered exposed to power unless confined within a block as defined in ANSI/NFPA 70® [Ref 7] (Section 800.2).

7.3 Buried Plant

Buried facilities are subject to exposure to lightning. Outside plant is not safe from lightning solely because it is buried below the earth's surface. A buried broadband cable or wire can become a conductor of lightning currents resulting from nearby strokes to the earth. In locations exposed to lightning, buried all-dielectric optical fiber cables may be subject to collateral damage during an arcing event of lightning to nearby underground metallic objects.

Inter-building broadband cable runs of 140 feet (43 meter) or less, directly buried or in underground conduit where a continuous metallic cable shield or a continuous metallic conduit containing the cable is bonded to each building grounding electrode system should be considered as unexposed to lightning. Examples are campus environments and short inter-building cables.

Joint random buried broadband facilities are considered to be exposed to power contact. Even though considered unexposed to power contact, direct buried broadband facilities that parallels power conductors for long distances is subject to power fault induction and, regardless of parallel distance, is subject to GPR resulting from power faults and should be classified as exposed.

7.4 Underground Plant

In metropolitan areas, underground broadband facilities are usually not exposed to lightning because of the shielding effects of tall buildings and buried metallic pipe systems. Underground broadband facilities are exposed to lightning in rural and suburban areas unless the broadband facilities are located where low incidence of thunderstorms and low ground resistivity prevails. Underground construction methods, by design, help to eliminate the possibility of power contacts, but not exposure to power fault induction and GPR.

7.5 Bridges, Overpasses, Submarine Plant

The exposure classification of broadband facilities in conduit on bridges and overpasses is considered to be that of underground broadband facilities. Broadband facilities mounted on bridge supports are treated as aerial broadband facilities. Submarine broadband facilities are regarded as buried broadband facilities.

7.6 General electrical Protection Measures

General electrical protection measures include separation and clearances, shielding, bonding and grounding, cable dielectric coordination, and the application of fuse links where there is the possibility of contact between the broadband cable facilities and commercial power conductors.

7.6.1 Separation & Clearances

Proper separation and clearances between broadband facility cables and conductors, and commercial power conductors shall be observed. Outside plant installations shall meet, as a minimum, the separations and clearances rules of ANSI/IEEE C2® [Ref 1]. Observance of the ANSI/IEEE C2® [Ref 1] rules reduce the likelihood of contact between commercial power and communications conductors in aerial, buried, and underground plant installations. In joint use aerial plant, separation and clearance rules provide adequate and safe climbing and working space for communications and power technicians to work safely in their allocated space. In buried and underground plant, separations rules reduce the likelihood of contact between power and communications facilities, and also reduce the likelihood that communications personnel will unknowingly contact energized power conductors. Although proper separation and clearance rules are followed, it is still possible for broadband outside plant to experience commercial power influences in the form of power contact, power induction, or GPR.

7.6.2 Bonding & Grounding

Bonding and grounding of metallic outside plant broadband facilities serve to equalize potential between metallic parts and provides a means for potentially damaging lightning and power fault currents to be directed away from the broadband outside plant facilities. Bonding and grounding requirements differ, depending upon whether the broadband outside plant is aerial (joint-use or single-use), direct buried, or underground in ducts or conduit. Specific bonding and grounding rules are given in 7.7.

7.6.3 Shielding

Shielding is intended to protect the broadband cable facility from the influence of commercial ac power systems and from Electromagnetic Interference (EMI). Two types of shielding are considered. The first type of shielding is *physical shielding* where, in a joint use aerial arrangement, a lower-voltage power distribution system (such as the secondary of an MGN system) or grounded neutral conductor is placed between the primary power distribution system and the broadband communications system. The lower-voltage power system or grounded neutral conductor provides an "umbrella of protection", shielding the broadband communications system from contact by the primary commercial power distribution in the event of failure of the power conductor(s) or supports.

The second type of shielding is *electrical shielding* which may be divided into two sub-categories: *electrostatic* and *electromagnetic*. *Electrostatic induction*, usually associated with high voltages such as might be present on high voltage transmission lines, may affect broadband facilities. However, grounding of metallic components is generally an effective means of electrostatic shielding.

Electromagnetic induction occurs when unbalanced currents on commercial ac power systems cause power-related voltages to be induced into metallic communications conductors. This is most common in, but not restricted to, MGN commercial ac power distribution systems. Electromagnetic shielding is accomplished through the use of a continuous metallic cable component that fully surrounds the metallic communications conductor(s) of the cable. Shield currents serve to mitigate or reduce commercial ac power-related voltages appearing on the communications signal conductors. Non-metallic cables, such as all-dielectric optical fiber cable, are not subject to electromagnetic induction. Coaxial cables -- because cable runs are typically short and well shielded – are not subject to levels of electromagnetic induction sufficient to cause equipment damage. However, electromagnetic induction may affect the functionality and service quality of coaxial cable-based broadband systems.

Although electromagnetic induction into coaxial cable distribution systems may be minimal, coaxial cable distribution systems in joint use with commercial ac power systems are subject to *resistive coupling*. *Resistive coupling* occurs when the coaxial cable shield, bonded to the neutral of the power distribution system for safety, provides an alternate path for the power distribution system neutral current. Because of the finite resistivity of the coaxial cable shield, the shield current will cause voltages to be coupled into the coaxial cable, appearing between the center conductor and shield. The magnitude of the coupled voltage is dependent upon the shield current and the physical properties, such as resistance, of the coaxial cable shield.

7.6.4 Cable Dielectric Coordination

When dealing with paired-conductor cable outside plant, dielectric coordination should be considered in high lightning areas. Failure to consider cable dielectric coordination can result in arcing within the lower dielectric cable during lightning events, resulting in damage to the cable. As an example, consider a plastic insulated (PIC) branch cable that is exposed to lightning that connects to a pulp insulated cable[6] that is unexposed. The high dielectric capability of the PIC cable will preclude arcing and damage to the PIC cable, but the lightning will be brought into the lower-dielectric pulp insulated cable where arcing and cable damage can occur. Care should be taken to coordinate cable dielectric capabilities, or to install cable protection at junctions of high-dielectric cable that is exposed to lightning with low-dielectric cable. Dielectric coordination is not an issue with all-dielectric optical fiber cable, which contains no metallic components, or with coaxial cable which has extensive dielectric capability between the center conductor and the shield.

7.6.5 Fuse Links

Fuse links shall be installed in metallic outside plant between the point of possible power contact and the protector at the customer or headend location. The fuse link limits power contact currents to a value that can be safely handled by the protector. Fuse links are not applicable to optical fiber cables.

[6] Pulp cable is a twisted-pair cable design that uses paper as the insulation for the conductors. The design is no longer manufactured but may still be found installed and in use in older plant.

7.6.6 Support Strand Ampacity (I^2t)

The support strand physically supports the broadband aerial cable plant and additionally – through bonding to the MGN – serves to minimize fault voltages, localize damage, and provide a low impedance path for fault de-energization in the event of a power contact. To accomplish these electrical protection objectives, the support strand must be capable of carrying the fault current until fault-clearing devices on the power system can operate. Support strand current-carrying ability or ampacity is expressed as $\mathbf{I^2t}$, where **I** is the estimated fault current resulting from a power contact to the strand and **t** is the estimated total fault clearing time (time to operate a power system fuse or breaker) in seconds.

7.7 Specific Electrical Protection Measures

7.7.1 Aerial Plant & Equipment

Electrical protection measures for aerial paired conductor cable, optical fiber cable, or coaxial cable – either singularly or in any combination – are covered in ATIS-0600316 [Ref 5], Clause 7. ATIS-0600316 [Ref 5], Clause 7, addresses bonding and grounding requirements, cable protection (cable dielectric coordination), joint use requirements, fuse link requirements, support strand ampacity, and armor-protected cable.

7.7.1.1 Additional Considerations for Aerial Coaxial Cable Plant & Equipment

When using only coaxial cable, bonding between the ground terminal of the protector or the bonding block and power ground need only be verified at joint use voltages of 34.6 kV and higher to ground. The support strand shall be bonded to the MGN at every active or passive apparatus at joint use voltages of 11.6 kV to ground or higher, except when there is a bond at an adjacent pole.

7.7.1.2 Protection of Coaxial Cable Apparatus

Active and passive coaxial cable apparatus shall be bonded to the MGN. If the MGN is not available, bond to a grounding electrode, such as a driven rod. Active and passive coaxial cable apparatus, including the coaxial output of power supplies, should include electrical protection. Such electrical protection is often included in the power path, internal to the apparatus. Typically, a single power-path protector provides voltage limiting for all power-passing ports of the apparatus.

7.7.2 Buried Plant & Equipment

Electrical protection measures for buried paired conductor cable, optical fiber cable, or coaxial cable – either singularly or in any combination – are covered in ATIS-0600316 [Ref 5], Clause 8. ATIS-0600316 [Ref 5], Clause 8, addresses bonding and grounding requirements, joint use and joint random requirements, fuse link requirements, and armor-protected cable.

Additional safety guidelines on grounding and bonding practices for buried and underground plant are also found in Section 35 of ANSI/IEEE C2® (NESC®) [Ref 1].

7.7.2.1 Additional Considerations for Buried Coaxial Cable Plant & Equipment

No special bonding and grounding measures are required for buried coaxial plant. Where excessive lightning damage to buried coaxial cable plant has been experienced or is anticipated[7], the use of shield wires should be considered to divert the lightning energy.

7.7.3 Underground Plant & Equipment

Electrical protection measures for underground paired conductor cable, optical fiber cable, or coaxial cable – either singularly or in any combination – are covered in ATIS-0600316 [Ref 5], Clause 9. ATIS-0600316 [Ref 5], Clause 9, addresses bonding and grounding requirements. In general, there are no fuse link or joint use requirements as underground plant and equipment is generally considered unexposed to power contact. However, underground plant and equipment may be subject to the effects of lightning and electromagnetic induction. As with paired cables, coaxial cable shields and equipment cases shall be bonded together in manholes and connected to the manhole grounding system. Coaxial cables need not be bonded at pull-through manholes.

8 Customer Locations

8.1 Exposure & Electrical Protection Considerations

8.1.1 General

Conditions for determining the exposure of the entrance facilities at customer locations are outlined in 4.2.1.1 of this standard.

Basic electrical protection measures at entrance facilities include the bonding and grounding of metallic members of telecommunications network plant (paired conductor cable, coaxial cable, optical fiber cable, service wire) serving the customer structure or building. Electrical protection may include isolation techniques where appropriate. If the broadband telecommunications network plant, broadband network provided power service, commercial ac power service, or the customer structure or building is classified as exposed (see Clause 4.2), then additional protective measures shall be applied to non-effectively grounded conductors entering the facility as discussed in 8.2.

By their very nature, antennas and antenna structures may increase or create facility exposure to lightning. Broadband wireless systems usually involve high frequency (microwave) transmission and small size antennas such as used in Very or Ultra Small Aperture Terminal systems (VSAT or USAT). Broadband wireless links can involve terrestrial or satellite locations, thus determining the required physical and installation characteristics of the antenna and the associated equipment. Antennas can be mounted in various locations at customer premises including standalone (ground level, pole, or tower) or attached (roof or wall) installations. Basic protection measures for such systems involve selecting a practical antenna location with minimal exposure, bonding, and grounding of the non-energized metallic members of the antenna, associated serving terminal (ODU), and metal supporting structures. Additional protective measures should be considered in exposed, elevated locations.

Installation of roof-top antennas might change the level of exposure of the building. Refer to the Risk Assessment Guide contained in Appendix L of ANSI/NFPA 780® [Ref 8] to evaluate the need for a Lightning Protection System (LPS).

[7] See Clause 15 of ATIS-0600328 [Ref 104], for more information on baseline threats from lightning.

8.1.2 Unexposed Locations

8.1.2.1 Short Below-Ground Cable Runs

Interbuilding cable runs of 140 feet (43 meter) or less, directly buried or in underground conduit, where a continuous metallic cable shield or a continuous metallic conduit containing the cable is bonded to each building grounding electrode system, should be considered as unexposed to lightning. Examples are campus environments and short inter-building cables.

8.1.2.2 All-Dielectric Cable

All-dielectric fiber optic cable should be excluded since it contains no metallic members. However, in locations exposed to lightning, buried all-dielectric fiber optic cable may be subject to mechanical or thermal (burning, melting) collateral damage owing to the arcing event of lightning striking nearby objects.

8.1.2.3 Small Radio Installations in Protected or Unexposed Locations

Small size wireless antennas, such as found in VSAT or USAT systems which are mounted in unexposed locations or within the zone of protection of the facility (see ANSI/NFPA 780® [Ref 8]) and do not increase the exposure index of the facility, should be considered unexposed to lightning.

8.2 Application of Protection Measures At Customer Locations

8.2.1 General Network Interface Unit (NIU) Considerations

The broadband telecommunications network plant interface at the customer location shall be provided within the NIU. Demarcation and interconnect functions shall be logically grouped within the NIU. In addition, the NIU may provide housing for protection means and other network equipment specific to the provided service or services.

In broadband wireless installations the NIU intercepts or terminates the IFL. Also, IDU equipment may be partially or fully integrated with the NIU. When the power to the ODU is derived from the IDU the in-premise extension of the IFL may carry AC or DC current.

Generally, the NIU is a multi-port device with separate ports dedicated to broadband telecommunications network plant (drop cable or IFL) and to customer interface. All working and non-working NIU ports shall be individually classified as exposed or unexposed based on the facility classification of Clause 4. Customer ports (circuits) should be usually considered unexposed except when the service cable or the serviced facility is remote and classified as exposed. The NIU shall be considered as exposed if one or more ports of the NIU are classified as exposed. Specified protection means shall be applied to all exposed ports of the NIU.

8.2.1.1 National Electrical Code Considerations for Derived Circuits

The NIU may provide a variety of circuits derived from the broadband telecommunications network or from the served facility. The typical circuits derived from an NIU are described in ANSI/NFPA 70® (NEC®) [Ref 7] as follows:

- Network-Powered Broadband Communications Systems (Article 830)
- CATV and Radio Distribution (Article 820)
- Conductive and Non-conductive Fiber Cables (Article 770)
- Class 1, class 2, and class 3 remote-control, signaling, and power limited circuits (Article 725)
- Power-limited fire alarm circuits (Article 760)

- Customer Premises-Powered circuits (Article 840)

8.2.1.2 Load Coordination of the Derived Circuits

NIU protection characteristics may be adversely affected by the load impedance applied to one or more of the derived circuits. However, listing of the NIU should involve a wide testing under a representative sample of all common loads and load combinations that may be applied to the circuits derived from the NIU.

8.2.2 NIU Bonding Terminal

The NIU shall provide a common reference bonding terminal. The common bonding terminal of the NIU shall be effectively grounded through bonding to the acceptable ground (see Clause 8.2.5).

8.2.3 Protection of Exposed Ports

Primary protection shall be provided on the conductors of the exposed ports of the NIU as described in Clause 8.2.4.

ANSI/NFPA 70® [Ref 7], Articles 830 and 250 detail grounding requirements for the primary protector and the metallic members of the serving telecommunications network plant. Included are the requirements for the grounding conductor, grounding electrode system, and connections.

When exposure to power contact greater than 300 volts rms to ground exists, a fuse link or equivalent shall be applied in the telecommunications network plant in addition to the primary protector.

8.2.4 Protector(s) Location

ANSI/NFPA 70® [Ref 7] (Article 830) recognizes that the protectors may be either internal or external to the NIU. External protectors may be applied to the broadband telecommunications network plant ports of the NIU or to the derived (customer) ports as required. All primary protectors and NIUs shall be listed for the purpose by a Nationally Recognized Testing Laboratory (NRTL).

The primary protectors attached to the exposed ports of the NIU shall be located in, on, or immediately adjacent to the structure or building served and as close as practicable to the point at which the exposed conductors enter or attach to NIU. The primary protector and the NIU may be located either on the outside or the inside of the structure or building being served. The primary protector or protectors and the NIU shall be located as to achieve the shortest practicable primary protector or protectors grounding conductor and the shortest practicable NIU grounding conductor.

The primary protector should be located in close proximity to the entering ac power service, especially in structures or buildings with multiple lines or circuits. This keeps the length of grounding and bonding conductors short and facilitates intersystem bonding between the telecommunications and power services.

The ground terminal of the listed protector internal to the NIU shall be bonded to the common reference bonding terminal of the NIU and the common reference bonding terminal of the NIU shall be effectively grounded.

The common reference bonding terminal of the NIU shall be considered effectively grounded if bonded to the effectively grounded ground terminal(s) of the external NIU protector(s).

8.2.5 Acceptable Grounds

Acceptable grounds for the primary protector are listed in order of preference. When electric power is present at the customer structure or building, the primary protector grounding terminal shall be connected to:

a) *The nearest accessible location on the electric power grounding system*. This may consist of the following:
   - A power grounding electrode conductor;
   - A metallic service entrance conduit;
   - An external connector provided on the service panel or raceway, sometimes referred to as an intersystem bonding termination.

   When electric power is not present at the customer structure or building, or power is present, but an acceptable ground as detailed above is either inaccessible or unavailable, the primary protector grounding terminal shall be connected to:

b) *The nearest accessible location on the building grounding electrode system*. The building grounding electrode system is a bonded-together assembly of any of the following types of electrodes available at the customer's structure or building:
   - A metal underground public or private water pipe with at least 10 feet (3 meters) in contact with the earth;

     NOTE - When a metallic cold water pipe serves as the telecommunication's primary protector grounding electrode, it shall be supplemented with an additional grounding electrode per ANSI/NFPA 70® [Ref 7], Article 250.
   - Effectively grounded building steel or metal building frame;
   - A buried, concrete encased, electrode as described in ANSI/NFPA 70® [Ref 7], Article 250;
   - A buried ground ring as described in ANSI/NFPA 70® [Ref 7], Article 250.

c) *Interior metallic water pipe that is bonded to the electric power ground* within 5 feet (1.5 meters) from the point of entrance to the building. However, because of the increased use of nonmetallic water pipe and plastic water meters, care should be exercised when selecting this type system. (Restrictions on the use of the interior metallic water pipe per ANSI/NFPA 70® [Ref 7], Article 250.50.)

d) *If the structure or building lacks a grounding means described above, then a ground rod not less than 5 feet (1.5 meters) in length and not less than 1/2 inch (12.5 millimeters) in diameter shall be used*. The ground rod shall be bonded to the interior metallic water system, if present, with a 6 AWG copper conductor per ANSI/NFPA 70® [Ref 7], Article 250.50.

8.2.6 Primary Protector Grounding Conductor Requirements

The grounding conductor shall be a listed insulated conductor. It may be either a solid or stranded conductor of copper or other corrosion-resistant conductive material. The primary protector grounding conductor shall be sized to safely conduct the anticipated currents from the maximum number of protected circuits. The grounding conductor shall not be finer (i.e., have a smaller diameter) than 14 AWG.

The grounding conductor shall be as short as practicable, but it shall not exceed 20 feet (6 meters) in length for one-family and multifamily dwellings. If it is not practicable to achieve the grounding conductor length of 6 meters (20 feet), a separate ground rod as described in 8.2.5(d) shall be driven, and the ground rod shall be bonded to the power grounding electrode system with not smaller than 6 AWG copper conductor. Similar grounding conductor length limitations are also recommended for apartment buildings and commercial buildings.

8.2.7 Multi-Port Protection

Through effective bonding of a signal conductor, the application of a single internal or external protector or effective grounding means may be extended to more than one port of the NIU. This may be accomplished through the use of frequency selective devices, non-linear devices, or multi-port protectors that isolate broadband signals from each other while providing effective bonding of each port (signal conductor) to the common protector or to the common bonding terminal of the NIU.

Such protection practice shall be permitted provided that all of the following are present:

- All exposed signal conductors are effectively bonded to the common protector or the common bonding terminal of the NIU;
- The NIU and, if used, the external common protector shall coordinate in current-carrying capacity including the condition of simultaneous exposure of all bonded signal conductors;
- The NIU and, if used, the external common protector shall be listed for the purpose.

8.2.8 Multiple NIUs

Multiple NIUs may be provided at a customer location. Common reference bonding terminals of all NIUs serving a customer location shall be effectively bonded and grounded to the acceptable ground.

8.2.9 Wireless Serving Terminal Bonding & Grounding

All, non-energized metallic members of the antenna, associated serving terminal equipment (ODU), and structural antenna supports, shall be bonded together. Grounding of the antenna-ODU structure shall be provided by means of the electrical continuous grounding conductor permanently connected between the antenna-ODU structure and the building grounding electrode system. In detached antenna installations an antenna grounding electrode system, bonded to the antenna grounding conductor at the antenna location, shall be applied. The antenna grounding electrode system shall be bonded to the building grounding electrode system.

8.2.9.1 Wireless Serving Terminal Grounding Conductor

The wireless serving terminal grounding conductor shall have a diameter no smaller than a 10 AWG solid or stranded copper conductor (ANSI/NFPA 70® [Ref 7], Article 820.21). In exposed locations and in detached installations with an antenna grounding electrode system, the grounding/bonding conductor shall not have a smaller diameter than a 6 AWG solid or stranded copper conductor. The grounding conductor shall be run in as a straight a line as practicable from the ODU to the antenna grounding electrode (if applicable) and building grounding electrode system.

8.2.9.2 Inter Facility Link (IFL) Installation Considerations

IFL cable(s) should be located in proximity to the antenna grounding conductor. Non-energized metallic members of the IFL cable(s) shall be grounded at both ends by means of connection to the NIU bonding terminal or metallic enclosure and the ODU/IDU bonding terminal or metallic enclosure. When a conduit is used for IFL installation, both the antenna grounding conductor and the IFL cable(s) shall be installed in the same conduit. Metallic conduits shall be bonded at both ends to the NIU and ODU bonding terminals.

9 Installation Considerations

9.1 General

The installation of electrical protection apparatus shall be performed in a workmanlike manner. Specific references to related standards or installation criteria are given as required at the appropriate clause within this standard. ANSI/NFPA 70® [Ref 7] requires that the primary protector, primary protector grounding conductor, and bonding and grounding equipment be listed for the purpose.

9.2 Objective

The objective of the electrical protection system is to remain functional for the life of the facility, and for the life of the customer structure or building. Correct installations shall be considered an integral part of the required functionality for the electrical protection systems.

9.3 Grounding Materials

Grounding material should be copper or copper alloy. Where other materials are used in conjunction with copper or copper alloys, care shall be exercised in providing for proper bi-metal coupling to reduce corrosion.

9.4 Grounding & Bonding Conductors

Grounding and bonding conductors shall be of sufficient cross-sectional area to safely conduct anticipated currents. Grounding conductors shall be of sufficient cross-sectional area to minimize voltage drops along their length during lightning and power fault disturbances. Grounding conductors shall be run in a direct manner with no sharp bends or narrow loops. Grounding and bonding conductors intended to connect to a grounding electrode in the communications network facility shall be in accordance with ANSI/IEEE C2® (NESC®) [Ref 1]. Grounding and bonding conductors intended to connect to a grounding electrode at a building or structure shall be in accordance with ANSI/NFPA 70® (NEC®) [Ref 7].

Grounding and bonding conductors intended for above ground installation shall be either stranded or solid, insulated or uninsulated. Grounding and bonding conductors that are in direct contact with the earth shall be solid copper wire, either insulated or uninsulated.

9.5 Conduit Use with Grounding Conductors

Grounding conductors should not be run in conduit unless they are vulnerable to mechanical damage or conductor support is required. When conduit is used, it should be nonmetallic. When the use of metallic conduit cannot be avoided, the grounding conductor shall be bonded to each end of the electrically continuous conduit with a minimum 6 AWG conductor.

9.6 Ground Rods & Bare Conductors

Where tinned or galvanized ground rods and grounding conductors are used, care should be exercised during installation so that surfaces are not damaged. Damage to the surfaces of the grounding elements may increase the potential for deterioration from corrosion.

9.7 Connections

Suitable methods for connecting grounding systems apparatus shall comply with ANSI/NFPA 70® [Ref 7] Article 250.

10 Equipment Grounding

10.1 Equipment in the Outside Plant

All nodes, active devices, passive devices, and power supplies – whether aerial or buried – should be grounded and preferably, bonded to the power system's MGN. On routes that do not have an MGN or the MGN is not readily available, a grounding electrode (ground rods, etc.) shall be used.

10.2 Grounding of ac Fed Equipment & Power Supplies

The commercial ac service which feeds the equipment located in the outside plant, such as power supplies, shall meet the applicable NEC requirements. The main disconnect panel in the equipment cabinet typically includes a neutral bus bar which connects the neutral (grounded) conductor, at the point of entry, to an earth electrode meeting the requirements of NEC® 250.50.

The main disconnect panel's neutral bus bar is typically bonded to the equipment ground bus bar via the main bonding jumper as required by NEC® 250.28. The cabinet, or equipment enclosure, shall be grounded by a bonding conductor to the equipment ground bus bar at the main disconnect panel. The entire assembly shall be listed for the purpose by a NRTL.